SOME OBSERVATIONS ON THE STEM HEMIPARASITE, OR MISTLETOE, *AMYEMA MIQUELII* (LORANTHACEAE), IN SOUTH-WESTERN AUSTRALIA

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In the Perth metropolitan area *Amyema miquelii* (Lehm. ex Miq.) Teigh is the most commonly occurring stem hemiparasite of Marri *(Eucalyptus calophylla)*, Tuart *(E. gomphocephala)* and Flooded Gum *(E. rudis)* but has never been recorded from Jarrah *(E. marginata)*. The Greek prefix 'hemi', refers to this plant's half, or partial, dependence on its host. Stem hemiparasites belonging to the Loranthaceae have green leaves and thus produce organic food by photosynthesis, but are dependent on the host for water and mineral salts. These nutrients are obtained by means of the hemiparasite grafting its vascular system onto the host's conducting elements. These stem hemiparasites are often referred to as 'Mistletoes' and were formally included in the genus *Loranthus* until the Australian taxonomic revision by Barlow (1966).

A. miquelii is not limited to the Perth metropolitan area but is found throughout Australia with the possible exception of the extreme north-east region of the continent. This species is usually parasitic on *Acacia* and *Eucalyptus*. In Western Australia, specimens in the Western Australian Herbarium and the Herbarium of the Botany Department, University of W.A. show *A. miquelii* has been recorded on ten species of eucalypt:—*Eucalyptus calophylla, E. ewartiana, E. gomphocephala, E. gongylocarpa, E. kingsmillii, E. oxymitra, E. patens, E. pyriformis, E. rudis, E. transcontinentalis* and *E. wandoo* (syn. *E. redunca* var. *elata)*.

The effect of severe infestation of Mistletoe being directly responsible for the death of the host has been suggested by Coleman (1949, 1950). However, this relationship is not all that clear, being dependent on the condition and age of the host, the conditions of growth and the number and size of infections present. It has been reported by May (1941) that heavy infestation of stem hemiparasites, affects the quality of timber and leads to a low production of flowers, pollen, honey and fruit. In cases of severe infestation the host may die, but death can be attributed to other factors such as, for example, age of the tree leaving it susceptible to hemiparasite attack, or secondary infection by fungal and insect pests. These may gain entrance through the gaps in the host tissue created by the hemiparasite. Hellmuth (1971) has conducted eco-physiological experiments on a related species of stem hemiparasite *(Amyema nestor)* in the arid region of the Cue area of Western Australia. His results showed that the field physiology of the host *(Acacia grasbyi)* when under stress conditions is affected by the hemiparasite. That is, the hemiparasite causes a water stress on the host which may lead to its death.

The extent of hemiparasitism of Marri and Wandoo *(E. wandoo)* can be easily observed on the roadside verges along Albany Highway. Unlike many other members of the *Loranthaceae* which exhibit perfect mimicry of the host, *A. miquelii* can be readily recognised by the densely branched clumps of foliage resembling inverted 'beehives' and the pendulous orange-pigmented foliage, contrasting with the grey-green, scattered leaves of its host (Fig. 1, Plate 1A and B).

At a site 1.6 km south of Mount Barker township (approximately 360 km south of Perth) and 6.5 km west of Albany Highway along St. Werburgh's Road, there is a stand of living and dead Wandoo, both severely infested with *A. miquelii* (Plate 1A). This patch of Wandoo occupies a strip 50 m wide between two paddocks. The area has been somewhat affected by mild burning and the understorey is dominated by *Hakea lissocarpha*. It was decided to look at this area in detail and study the host-hemiparasite relationship. A count of the number of hemiparasites per tree was carried out for a distance of 800 m, using St. Werburgh's Road as a transect. It was found that the dead trees had an average height of 10 m and carried from 14 to 42 dead hemiparasites per tree. These could be readily observed and counted due to their terminal position, intricate branching and in many cases a lime, yellow/green colour caused by the lichen *Candelariella vitellina*. This lichen appears restricted to the rough broken bark of the hemiparasite and is not found on the smooth and shedding

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Figure 1.—A. *Amyema miquelii* showing general morphology. B. Single flower from inflorescence triad.

bark of the host. However, these counts probably do not represent the total number of hemiparasites per tree as there is a tendency for dead specimens to snap off. This may be due to their weight and terminal position, combined with the frequent loss of brittle branches during strong winds. Many specimens

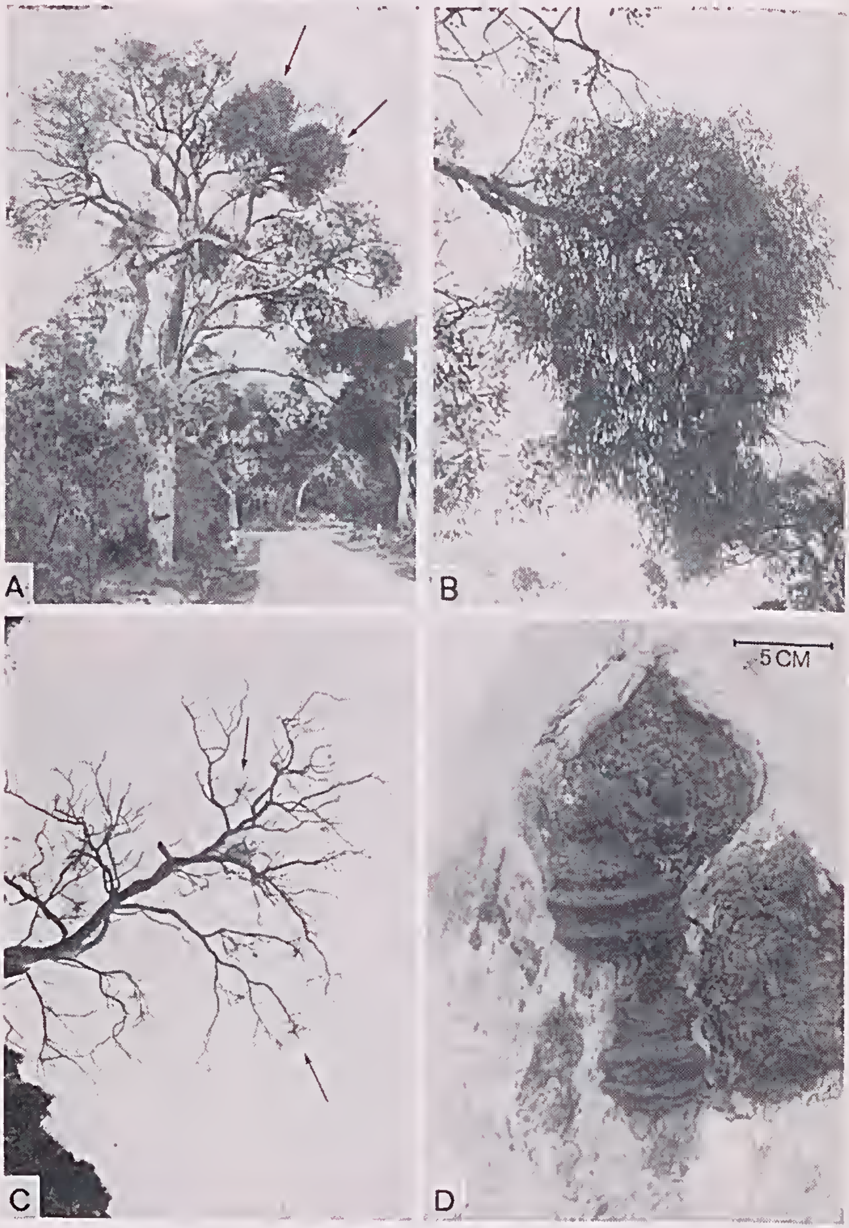

Plate 1.—A. General view of St. Werburgh's Road study site. Two dense clumps of foliage due to *A. miquelii* are arrowed. B. Single plant of *A. miquelii* showing terminal position, inverted "beehive" shape and pendulous branches and leaves. C. Part of a dead Wandoo showing numerous terminal, intricately branched remains of *A. miquelii*. D. *Fomes rimosus* on the trunk of Wandoo.

of *A. miquelii*, broken off immediately below the haustoria, were found under the dead trees.

Three of the trees in the group had both living and dead hemiparasites. It appeared that the branches being parasitized had died back thus killing the parasite. Death of the branch is probably due to the hemiparasite cutting off supplies of water and mineral salts from that part of the branch beyond the point of infection. As the hemiparasite develops at the expense of the host, loss of host foliage occurs. Often this part of the branch is so injured that it dies back and is shed, the mistletoe then assuming a terminal position (Plate 1C). Because of this, the host plant often develops a straggling profile and in cases of severe infestation (such as the St. Werburgh's Road study site) there is a resultant loss of symmetry caused by reduction in canopy.

An analysis of variance was applied to the results obtained and these tended to support observations made in the study area. There was a significant difference between the numbers of hemiparasites occurring on living and dead trees (Table 1, A). On average, the dead trees bore twice as many parasites as the living trees. On comparing trees with only living hemiparasites against those with both living and dead hemiparasites, a very high significant difference was obtained (Table 1, B), the latter group containing over three times the number of the former group. One must keep in mind that this significance would be even higher if allowance was made for all the dead hemiparasites which had already fallen to the ground. Continuing observations on the trees with both living and dead hemiparasites has shown a further reduction in canopy, and in one tree death appears to be imminent.

TABLE 1—STATISTICAL ANALYSES ON THE NUMBER OF HEMIPARASITES RECORDED PER TREE AT THE ST. WERBURGH'S STUDY SITE.

A

	LIVING TREES	DEAD TREES	F
No. OF TREES	18	6	
MEAN No. HEMI-PARASITES/TREE	11.9	22.3	5.52*

B

	LIVING TREES WITH LIVING HEMIPARASITES	LIVING TREES WITH LIVING AND DEAD HEMIPARASITES	F
No. OF TREES	15	3	
MEAN No. HEMI-PARASITES/TREE	8.7	27.7	32.62***

* denotes significantly different at 5% level.
*** denotes significantly different at 0.1% level.

As May (op. cit.) has shown, secondary infections by fungi may contribute to the host's death. At the study site several trees were found to be infected by the wood attacking fungus, *Fomes rimosus* Berk (Fig. 1D). This species has been shown by Tamblyn (1937) to cause a 'Honeycomb Pocket Rot' of Wandoo. The hyphae of this species invade the heartwood and sapwood of its host, thus reducing the plant's capacity to conduct water. Coupled with the demands of the stem hemiparasite, water stress must be increased. The horse-hoof shaped basidiocarps (spore bearing bodies) were collected from the trunks of Wandoo infested with *A. miquelii*—but none from the trees that had died.

In speculating as to the reasons why this group of Wandoo is so severely infested by *A. miquelii* one must look briefly at the biology of the hemiparasite itself.

The biology of this hemiparasite, especially the dissemination of the species, is rather intriguing and has been well documented (see Kuijt, 1969; Johri and Bhatnagar, 1972). From the pendulous red flowers, a fleshy 'berry' develops which is attractive to small animals, especially members of the genus *Dicaeum*, the so-called 'Mistletoe-bird'. This genus is represented by *D. hirundinaceum* in Western Australia. Birds carry away the turgid, ripened fruits which on pressure extrude the seed which is surrounded by a sticky, viscid layer. The viscid layer around the seed is said to act not only in securing an attachment to some object but also in providing moisture during germination (Johri and Bhatnagar, 1972). The seed may be wiped by the bird from its beak onto the host, or in the majority of cases, the seed is ingested by the Mistletoe-bird. These birds are adapted to this specialised diet. The muscular portion of the stomach (the gizzard) has virtually disappeared and the alimentary canal (including the oesophagus, glandular portion of the stomach and the intestine) appears superficially to be an even duct with no enlargements (Serventy and Whittell, 1967). Another characteristic these authors point out is that the Misteletoe-bird defaecates sitting along, and not across a branch, so that the seeds become attached to the branch.

Observations on the Mistletoe-bird at the St. Werburgh's Road study site are limited for the same reasons that both Coleman (1950) and Cayley (1967) point out. That is, these birds frequent bushy trees, fly high over tree tops and rarely stay still. However, studies in Indonesia by Doeters van Leeuwin (1954) has shown that the Mistletoe-bird moves along a twig when defaecating, while its body rocks rapidly from side to side, thus effectively pasting the seeds to the branch. The same worker in an attempt to look at the range of dispersal of the seeds, measured the time taken for Mistletoe-birds feeding on the berries, to defaecate the seeds. These times ranged from 4-12 minutes.

Once the seed is attached, it germinates spontaneously, the radicle being firmly applied to the surface of the host branch forming an adhesive cushion, or holdfast. The haustorium (a peg-like structure), develops from the centre of the holdfast and penetrates into the cortex of the host. The penetration is usually affected through some weak portions, like lenticels and cracks. It is generally agreed that both chemical and mechanical forces take part in the process of penetration of the haustoria (Johri and Bhatnagar, op. cit.). The hot tissue reacts to the entry of the haustorium and a characteristic swelling results, forming a 'burr'.

One can only speculate as to the reasons why the St. Werburgh's Road group of Wandoo is so severely infested by *A. miquelii*. Experiments by May (1941) have shown that Mistletoes have a high light requirement. This worker conducted experiments on seeds of *A. miquelii* and found that embryos placed in the light gave a 91 per cent germination, while those kept in darkness gave 44 per cent. This helps to explain why Mistletoe is more common on road verges or disturbed land, than virgin forest.

It is generally stated that Wandoo forms a more open vegetation type than does Jarrah (Forestry in Western Australia, 1971) though few published records of their respective canopy cover are available. Data from the use of an importance index, based on relative frequency, relative density and relative basal area of tree species has been used by W. A. Loneragan (unpub. data) to classify 76 sites into either Wandoo dominated or Jarrah dominated. Of these,

TABLE 2.—SUMMARY OF CANOPY COVER DATA FOR WANDOO-DOMINATED AND JARRAH-DOMINATED SITES

	WANDOO	JARRAH
No. OF SITES	34	42
MEAN CANOPY COVER	21.47	27.44
VARIANCE	150.45	147.67
STANDARD ERROR	2.10	1.73
VARIANCE RATIO	1.02 NOT SIGNIF.	
't' VALUE	—2.19 p < 0.05 0.0.5 > p > 0.02	

34 sites were classified as Wandoo dominated and 42 as Jarrah dominated. Canopy cover data using a crown cover densiometer (Lemmon, 1956) was also available for these sites. The average of 4 sampling points being taken as an estimate of the mean cover of the species on each site.

The mean canopy cover of Wandoo in the 34 Wandoo dominated sites and of the Jarrah in the 42 Jarrah dominated sites was calculated, and their difference tested for significance. Since the variances of the two sample groups are not significantly different ($F = 1.02$, critical value $p = 0.05$; $F \simeq 1.51$) the conventional 't' test for unpaired data was used. The results of this test (Table 2) show that the canopy cover of Wandoo in the Wandoo dominated sites is significantly less than the canopy cover of the Jarrah in the Jarrah dominated sites. This open canopy may provide the high light requirement necessary for Mistletoe germination and explain the more frequent occurrence of Mistletoe in the Wandoo woodlands.

In the case of the St. Werburgh's Road study site, the position of the stand of Wandoo forming a corridor between two cleared paddocks and sited near a water source (a tributary of the Hay River) may form a habitat for the Mistletoe-birds. Once the hemiparasite had become established, the feeding habits of the birds and the ease with which they promote seed dispersal would result in further infection. Slowly, the canopy of the Wandoo would be removed as branches die, allowing further areas of increased light suitable for hemiparasite germination. As hemiparasite numbers increase the area attracts more birds to feed on the larger amount of Mistletoe berries. The incredible number of Mistletoe plants in a small area such as those at the St. Werburgh's Road study site could be the result of these processes. Further study is needed on the host-Mistletoe-Mistletoe-bird relationship in order to understand the reason for the heavily infested trees frequently encountered.

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